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ART. V.—*Petrology of the Tertiary Older Volcanic Rocks of Victoria.*

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Contents.

Introduction.

The general division of the Tertiary lavas of Victoria into an Older Volcanic Series (Miocene or earlier) and a Newer Volcanic Series (Pliocene to Recent) was introduced by the early Geological Survey of Victoria. The conception was based on the relationships of the lavas in the Port Phillip district to fossiliferous marine beds, and was then extended by "conjecture or analogy" to lavas in other parts of Victoria. The evidence for correlation often appeared slender or doubtful, and there was little to indicate "whether the Older Basalts (Older Volcanic Series) were contemporaneous or part of a series of eruptions extending over a long period" (39).

The detailed study of these lavas has barely been begun, but a representative collection from most of the outcrops correlated with the Older Volcanic Series is now available. The collection comprises about 300 thin sections of lava flows and about 350 sections of dykes. The specimens from which these were made were gathered chiefly by officers of the Geological Survey of Victoria, but notable additions have been made by Messrs. W. McCance, A. Coulson, and R. Jacobson, and the author.

Petrological examination of this collection makes it possible to advance from the position outlined by Professor Skeats in 1910 (39, p. 201), and present a more comprehensive study of this igneous suite. Since the Newer Volcanic Series has also been studied in considerable detail (12), it is also possible to make a precise comparison of the Older Volcanic lavas with those of the Newer Volcanic Series.

The Older Volcanic Series.

SUMMARY OF CONCLUSIONS.

For convenience of presentation, the conclusions arrived at in the petrological section of this paper are summarized here. The Older Volcanic Series is a distinct petrological suite comprised of crinanites, olivine-titanaugite-dolerites, olivine-titanaugite-basalts, olivine-basalts, olivine-nephelinites, limburgites, and monchiquites, camptonites, and possibly acid differentiates in the form of tinguaites and phonolites. This association is closely comparable with the late Palaeozoic igneous suite in the west of Scotland (51), and also with the Tertiary "plateau magma" suite of Scotland (25). The probable composition of the Older Volcanic parent magma is similar to the Scottish plateau magma type, and corresponds to Kennedy's "olivine-basalt magma type" (26). This must not be confused with the "plateau basalts" of Washington (52), which constitute the "tholeiitic magma type" (26) of Kennedy, or the "non-porphyritic central magma type" of Scotland (25). No tholeiitic rocks appear to occur in the Older Volcanic Series.

It has been found also that the Older Volcanic suite is distinct from the Newer Volcanic, both in the nature of many of its rocks and in the probable composition of its parent magma. While the Newer Volcanic parent magma is also an "olivine-basalt magma type," it has some pronouncedly tholeiitic features.

The presentation of these results is the more apposite in view of a recent publication by Sussmilch, in which he states (50, p. 26) :—"The basalts of Victoria apparently belong to at least four distinct geological periods (*a*) Oligocene, (*b*) Lower Miocene, (*c*) Lower Pliocene, (*d*) Pleistocene to Recent. Under these circumstances the use of the terms Older and Newer Basalts (i.e. Volcanics) is misleading, and has led to much confusion, and it would be better if both terms were dropped."

In making this statement, Sussmilch has placed too much emphasis on the "distinctness" of these four periods. They represent a continuous passage of time. He has also overlooked two features of volcanic rocks, one of which is a tendency to intermittent eruption over a considerable period of time; the other, that rocks from a common stock possess common characters.

As is shown in subsequent pages, the Victorian basalts are divisible, on petrographic grounds, into two fairly well-defined and widespread suites. One of these suites includes lavas of a pre-Miocene to Miocene age. The other includes lavas of a Pliocene to Recent age—in other words, they correspond to an Older and a Newer Volcanic Series. This being so, the terms Older Volcanic Series and Newer Volcanic Series are neither misleading nor confusing, but express clearly and adequately the conception of two periods of volcanic activity.

It seems possible that these two eras of volcanic activity were only maxima in a single great period, the extensive Older Volcanic extrusions dying away during the Miocene to a few minor extrusions, and recurring in the Pliocene after a period of rest and renewed differentiation, as has been suggested by Skeats and

Summers (45, p. 53). These two periods of intense activity must themselves have been diversified by fluctuations in intensity, and shifting of the centres of extrusion.

Distribution and Field Occurrences.

The Older Volcanic Series includes both lava flows and dyke intrusions. These consist of practically identical rock types, but in different proportions, and the distribution is somewhat different.

Lava Flows.

The rocks constituting the lava flows are crinanites, titanaugite-dolerites and basalts, several varieties of olivine-basalt, and minor amounts of limburgites and nephelinite, and possibly acid alkaline rocks. Their age relations are well established in the Port Phillip district, where they occur beneath fossiliferous marine beds of Lower Miocene age, as at Flinders (27), Balcombe Bay, and Grice's Creek (38), Royal Park (37), Keilor (8), and in the vicinity of Geelong (7, and references), or intercalated between such beds, as at Maude (7).

In South Gippsland the basalts pre-date the Tertiary faulting, and lie beneath the main seams of brown coal. This has been proved by diamond drilling at Warragul, Yarragon, Morwell, Boolara, and Welshpool. Stirling (49) and Herman (17) have shown that the deposition of the brown coals occurred intermittently over a considerably longer period than was required for the extrusion of the basalts, so that there are pre-basaltic, inter-basaltic, and post-basaltic brown coals. Thus, in Bore No. 1, at Yarragon, the following intercalation of brown coal and basalt was found (49, p. 74) :—

	Thickness of seam or lava. Feet.
Brown coal	17
Brown coal	24
Brown coal	67
Brown coal	8
Basalt	41
Brown coal	1
Basalt	45
Basalt	18[illegible]
Basalt	70
Basalt	108
Brown coal	2

Similarly, at Leongatha, in Bores Nos. 3 and 5, seams of lignite, 6 inches and 9 inches thick, were found between basalt flows. The pre-basaltic and inter-basaltic brown coal seams are generally very thin, and never attain the great thickness of the post-basaltic brown coals. The most extensive development of brown coal beneath the basalts in South Gippsland is at Elizabeth Creek, in Allambee East, where there is a seam 40 feet thick while in the neighbourhood are seams 12 to 20 feet thick (49).

The brown coals of the Latrobe Valley are generally regarded as of Oligocene or Miocene age (38). Similar brown coals at

Parwan, Altona, Tyabb, Tanjil, and in East Gippsland underlie fossiliferous Oligocene or Miocene beds (4, 5), while at Hedley, near Gelliondale, brown coal is found beneath beds containing Pliocene fossils. On these grounds the basalts of South Gippsland should be Miocene or older. Sussmilch (50, p. 25) has claimed, however, that they "cannot be older than Lower Pliocene"; but in the same paper (50, p. 15) he arrives at the conclusions that the uppermost beds of the Yallournian (i.e. brown coal series) are possibly as young as Lower Pliocene, which would still make the basalts at least as old as Miocene.

At Dargo (33), Darlimurla (35), Narracan (3), Berwick (9), Pascoe Vale (34), Flemington (37), Beenak (24), Grice's Creek (38), Mahaikah (19), and Bacchus Marsh (32), the Older Volcanic basalts are found associated with Tertiary leaf beds. These leaves have been referred to the Miocene, but are not generally accepted as affording a precise indication of age. Nevertheless, the similarity of the leaf remains does suggest a broad contemporaneity for the lavas associated with them. At Berwick the leaf beds overlie a bed of brown coal from 2 to 3 feet thick.

The other lines of evidence as to the age of the Older Volcanic rocks, especially in East Gippsland, are the physiographic, which is described by Hills (18), and the petrological, given here. Correlation on petrological grounds tends to be regarded with suspicion, because rocks which originate by similar processes of differentiation must necessarily be generally similar in appearance and composition, even though formed at widely separated geological periods. It often happens, however, that a group of consanguineous rocks will possess minor peculiar characteristics which readily distinguish it from another generally similar suite. This is fortunately the case in Victoria, where both the Older Volcanic and the Newer Volcanic suites contain types with distinctive features and of widespread occurrence, viz., crinanites and titanaugite-basalts in the Older Volcanics, and iddingsite-basalts in the Newer Volcanics, as well as other less marked differences that are set out more fully in a later section (p. 92). Moreover, it has been found that classification of such rocks as Newer Volcanic or Older Volcanic by their petrological characters agrees closely with determination of their ages by physiographic or stratigraphic methods. The results of this classification by petrological characteristics, together with the data, are summarized in Fig. 1, which shows the probable distribution of the Older Volcanic lava flows in Victoria.

Dyke Intrustions.

The dyke swarms that accompany the Older Volcanic lava flows are comprised of crinanites, titanaugite-dolerites and basalts, olivine-basalts, monchiquites, rare nephelinites, and occasional camptonites, with possibly a few dykes of tinguaite and phonolite.

The age relations of these dykes are often obscure. At Kangaroo Gully, near Bendigo, they appear to be post-Permo Carboniferous (41). At Korkuperrimul Creek, Jacobson (20) has found several dykes of monchiquite and nephelinite which penetrate the earlier Older Volcanic flows, but either fail to penetrate the later ones or merge into them, so that there can be no doubt of their contemporaneity with the lavas. Equally definite relations can be observed in the neighbouring parishes of Gorong and Yaloak. Here the dykes in some instances penetrate the Older Volcanic basalts, but they clearly pre-date the Newer Volcanic basalts and the Tertiary leaf beds which the Newer Volcanic basalts overlie. These dykes are monchiquites, camptonites, and olivine-basalts, accompanied by a plug of olivine-nephelinite. Similar monchiquites and a nepheline-monchiquite occur further south at Anakies, and the You Yangs monadnock, and others presumably occur in the intervening country, beneath the Newer Volcanic basalts.

This swarm of dykes continues northwards, becoming dominantly monchiquitic with a minor number of camptonites, as far as Bendigo and probably Tarnagulla. Such dykes have been recorded from Steiglitz (15), Blackwood (14), Ballarat (16), Daylesford (53), Castlemaine (15), Maldon 15), and Bendigo (48).

No dykes occur in the Jurassic rocks of the Barrabool Hills or of the Otway Ranges, which are thus in striking contrast to the Jurassic hills in South Gippsland, where there is a strong swarm of crinanite, basalt, and monchiquite dykes. The western limit of the dyke swarm may be placed, therefore, between the You Yangs (and Curlewis) and the Barrabool Hills. A search through the literature reveals records only of diorite and acid lamprophyre dykes in the goldfields west of Ballarat, such as Beaufort, Scarsdale, Maryborough, Bealiba, St. Arnaud, Avoca, Stawell, and Wedderburn. The lamprophyres are in the main described as minettes, and seem to be contemporary with the diorites (i.e. probably Devonian), and so distinct from the Older Volcanic lamprophyres which are camptonites, sometimes grading into kersantites. An approximate western boundary of the Older Volcanic dyke swarm can be drawn from this data (Fig. 2).

In South Gippsland the dykes outcrop only in the upthrown blocks of the Jurassic, from which the Tertiary sands and brown coal have been stripped (10). They have been found in occasional diamond drill cores in the downthrown blocks beneath the Tertiary sands. They therefore pre-date the faulting of the region, like the lava flows, and since they are not recorded as penetrating the Older Volcanic flows, they are probably either earlier or contemporaneous with them. At Flinders, on the other hand, dykes occur in the basalts of the shore platforms.

In Eastern Gippsland there is no indication of the age relations other than that of petrological similarity. It is impossible to distinguish the crinanites, olivine-basalts, monchiquites, and camptonites that comprise the dykes of this region from those of the several areas previously referred to. A further line of evidence that supports the conclusion that all these dykes belong to the Older Volcanic Series is that the wide areas of Newer Volcanic rocks that have been examined seem to be practically destitute of dykes, despite many favorable exposures in stream sections.

As will be seen from Fig. 2, the Central Victorian dykes are dominantly monchiquitic with subordinate camptonites and basalts. Basalts become more prominent in the vicinity of Gorong, and are accompanied by occasional dykes of dolerite and nephelinite. East of Melbourne the basaltic dykes are increasingly predominant. In South Gippsland crinanites appear, and with olivine-basalts make up the majority of the dykes. The monchiquites are still numerous, and persist into Eastern Gippsland where they are joined by camptonites, phonolites, and tinguaites. The crinanites and olivine-basalts also persist into this region.

The full extent and strength of the Older Volcanic dyke swarms can only be conjectured. Heavy soils and vegetation obscure out-crops, and the dykes weather rapidly to considerable depths, so that generally they can only be observed in cuttings, stream sections, or mine workings. Mapping, moreover, has often been limited to rapid surveys.

The northern boundary of the swarm is equally a matter for conjecture. No Tertiary dykes are recorded in the north-east of the State, i.e., north and north-east of the Buffalo Mountains, Mount Hotham, and Glen Wills, although mapping in that part has been fairly detailed. Another hiatus occurs in North-west Gippsland. Tertiary dykes have been mapped in the Walhalla-Wood's Point belt (22, 28, 54), but none are recorded from further north. They have also been found at Warrandyte, Kangaroo Ground, and near Lilydale, but not further north. The mapping in this blank area has so far been of a reconnaisance character, so that dykes may well exist there. Still further north, however, where mapping has been more intensive, none have been observed, and since a number of dykes have been recorded in equally sketchily-mapped areas of Eastern Gippsland, they cannot be prominent in North-west Gippsland, and may not occur north of the tentative boundary suggested in Fig. 2.

Petrology.

The outcrops of Older Volcanic rocks about Port Phillip Bay, which undoubtedly underlie Miocene beds, were selected as the type Older Volcanics, particularly those of the Mornington Peninsula, which have the most extensive outcrop, and have been explored by a number of diamond drill holes, the cores from which are available at the Mines Department. At Flinders one such bore was put down for more than 1,100 feet through a succession of basalt flows, while another at Cape Schanck penetrated about 800 feet of basalts.

The basalts in these areas contain abundant titanaugite and sometimes abundant analcite, combined with a relative absence of iddingsite, and are sometimes markedly ophitic in texture. They are distinct from the iddingsite-rich, titanaugite-poor basalts of the Newer Volcanic Series, but are identical with some of the dykes and volcanic necks of South Gippsland (10). These distinctive types are of wide-spread occurrence throughout Eastern and South-eastern Victoria, in association with other basalt types (Fig. 1), and serve as "marker flows" of a well defined petrological suite. Their presence among lavas of another area can be regarded as presumptive evidence that those lavas belong to the Older Volcanic Series, provided that there is no evidence to the contrary; and beginning with these types it has been possible to devise an approximate classification of the Older Volcanic Series into recognizable groups. In order to simplify subsequent discussion, local "type names," e.g., Keilor type, have been given to those groups which could not be given distinctive descriptive names.

Titanaugite Basalts.

Crinanites and Crinanite-basalts.

These doleritic olivine-analcite basalts occur in the lowermost flow of the Cape Schanck bore (700-850 feet), at Berwick (lower flow), at Kelly's Hill near Pakenham, at Gembrook, near Mardan, near Trafalgar, and at Narracan Creek (Allot. 125, Thorpdale), from Neerim to Noojee, at Leongatha, near Hallston, on the banks of the Latrobe River, north of Moe, and in diamond drill cores from the Dargo High Plains. They are coarsely ophitic rocks, and consist of a few embayed phenocrysts of olivine, which may be fresh or altered to serpentine, in a coarsely intergrown groundmass of plates of purple titanaugite up to 3 mm. across, and laths of labradorite (Ab_{35}-Ab_{40}) about 1.0-1.5 mm. long, coarse rods of ilmenite and needles of apatite, and interstitial analcite. The titanaugite sometimes encloses the olivine crystals. It is optically positive, with 2V about 60°, and pleochroic with X = purple-brown, Y = purple, and Z = yellow. Where it is in contact with analcite it may be altered to green aegirine-augite or even aegirine. The analcite is sometimes water-clear, but is more often cloudy and weakly birefringent. Flakes of biotite sometimes occur in association with the analcite and in cracks in the olivine. A finer-grained crinanite-basalt, showing flow arrangement in its groundmass, occurs at Warragul (Allot. 127).

These rocks cannot be differentiated from the crinanites which are so prominent among the north-west dykes of South Gippsland (10), and are probably co-genetic with them. No chemical analysis exists, but the composition must be closely similar to the analysis of the Gippsland crinanite shown in Table I., No. 1.

Ophitic-titanaugite-dolerites.

These differ from the crinanite-basalts only in the absence of analcite, and the minor amounts of aegirine and biotite. They occur at Korkuperrimul Creek, as the upper flow there (20), in the Dargo High Plain bore cores, at Upper Dargo, Cobungra, Mount Hotham, Mount Matlock, Yarragon, and on the Thomson River, and in the chilled base of the Neerim-Noojee crinanite, where it rests upon the Silurian. Similar rocks are found at Mallacoota and at Omeo as dykes.

Mooroodue Type.

A third group of closely comparable titanaugite-basalts occur in the Mooroodue bores (No. 8, 135-200 feet), Bittern bores (No. 2, 130 feet), Tyabb bore (No. 6, 404 feet), Flinders bore (No. 1, 0-99, 409, 536-671, 874-1135 feet), at Longwarry, in the Tangil bores at Bates Crossing (No. 4 and No. 7), Cape Schanck bore (No. 1, 43 feet), at Balnarring, Balcombe Bay, and San Remo, on the Bogong High Plains, in the bores from the Dargo High Plains, at Mother Johnson's Flat near Hotham, at Mahaikah, at Welshpool (bore No. 1, 440 feet), Toora (Allot. 15), at Berry's Creek, Mirboo (bore No. 20, 192 feet), in Devon (Allot. 103), at Maude, and at Russell's Bridge in the Geelong district, at the Korkuperrimul Creek, at Kangaroo Ground, Diamond Creek, and Greensborough, at Spring Plain, and Connor's Plain near Wood's Point, and at Flourbag Creek, Walhalla, at Livingstone Creek, and from a dyke in Collin's shaft near the junction of the Little Gibbo Creek with the Mitta Mitta. Similar dykes occur in South Gippsland (10).

These rocks are finer-grained than the previous groups. Olivine is the only mineral which forms phenocrysts. It may be fresh, corroded or, more frequently, altered to serpentine. The crystals range from 0.5 to 2.0 mm. in diameter, the smaller sizes being the more common. They are set in a medium-grained groundmass of violet titanaugite (2V about 60°), ophitic towards plagioclase laths (Ab_{40}), and abundant intersertal glass which is usually green, but sometimes yellow or brown. This glass is generally devitrified and birefringent, and is either chloritic or serpentinitic in composition (20). The degree of ophicity varies, as does the depth of colour of the titanaugite, and in chilled phases the pyroxene does not appear, but is replaced by an opaque glass which is packed with iron ore globules and is a purple or black colour. This glass resolves under high magnification into a colourless base crowded with trichytes of iron ore. Such chilled phases are found at Tangil, Moorooduc, Flinders, and Tyabb.

A variant of this type is found at Korkuperrimul Creek, in the second lowermost flows of the Older Volcanic rocks of that district (20). The amount of green glass is diminished, and phenocrysts of titanaugite up to 3 mm. in diameter are present. The groundmass is coarser, and the unusually elongated laths of the plagioclase have segregated into sheaves. This feature is present to a lesser degree in a flow at Balnarring. An analysis of the Korkuperrimul rock is given in Table I., No. 4.

The specimens from Spring Hill and Connor's Plain, near Wood's Point, contain a greatly reduced amount of brown glass; and in specimens near Thomson's Bridge over the Latrobe (Narracan), and from half a mile east of Arthur's Seat, Dromana, and from Gembrook it is absent.

Iddingsite-Basalts.

Iddingsite-bearing basalts are relatively uncommon among the Older Volcanics, and such as do occur are readily distinguished from the Malmsbury and Footscray types of iddingsite-basalt so prevalent among the Newer Volcanics (12).

Iddingsite-titanaugite-basalts.

The basalt which occurs as a shore platform at Portarlington (7) is a typical titanaugite dolerite, except for the fact that the olivine crystals are heavily rimmed with red-brown iddingsite even when enclosed by titanaugite. Similar iddingsitization is observed in places in the olivine-titanaugite-dolerite which forms the uppermost flow at Korkuperrimul Creek (20).

The porphyritic variation of the Moorooduc type which occurs as the second lowermost flow at Korkuperrimul Creek, also grades locally into an iddingsite-titanaugite-basalt. The flows which overlie this rock are characterized by iddingsite (20), but this is accompanied by pale violet augite (2V about 60°) which is frequently pleochroic, and by varying amounts of clear green, yellow, or orange glass. The abundance of titanaugite in these rocks, and the type of glass mentioned in the last, readily distinguishes these rocks from the Newer Volcanic types of iddingsite-basalt.

Mirboo Type.

Iddingsite-basalts also occur in the Berry's Creek bore (No. 20) near Mirboo, where they form two flows, the uppermost (4th flow) and the flow at 117-147 feet depth (2nd flow); in the Flinders bore, as several flows (about 160 feet, 215 feet, 300 feet, 500 feet, and 850 feet levels); in the Cape Schanck bore; and at Evelyn.

These basalts are all fine-grained, slightly glassy rocks, consisting of phenocrysts of olivine slightly altered to iddingsite, set in a groundmass of plagioclase laths (Ab_{45}), granular to idiomorphic crystals of colourless or pale-violet pyroxene, iron-ore grains, and a variable amount of green glass. Numerous vesicles of chalcedony and glass are present in the Berry's Creek rocks, and in some slides a little biotite is present. The alteration of the olivine to iddingsite is of uniform extent, and pre-dates the crystallization of the pyroxene of the groundmass, since iddingsitized olivine crystals are frequently observed enclosed by aggregates of pyroxene. Small grains of iddingsite are present in the groundmass. The rock from the lower flow at Berry's Creek is a chilled phase, in which the felspar was unable to crystallize to any extent, so that it has the appearance of a limburgite.

The olivine cores may or may not be altered to serpentine. Such serpentine as is formed is often bright green, pleochroic to a yellow green. In the Flinders specimens the olivine crystals reach dimensions such as 3-4 mm. across, with a very thin rim of iddingsite, and in one of the higher flows at this locality the iron-ore forms coarse octahedra larger than the individual pyroxene grains.

In the Flinders rock from the 215-ft. core, the iddingsite is the yellow variety (36). It is strongly pleochroic and shows straight extinction. A vein of iron-oxide stained rock appears in the slide. As this vein is approached the yellow iddingsite makes over to red iddingsite. Chalcedony is again present as vesicles and veins.

The 4th flow at Barry's Creek has been analysed, and the analysis is shown in Table I., No. 9. The richness in magnesia is due to the presence of much serpentine, both pseudomorphous after the olivine, and as the green glassy base.

Olivine-basalts.

Associated with these more distinctive types of basalt are several other variations in which titanaugite is rare or absent.

Keilor Type.

A distinctive type of glassy olivine-basalt occurs at Green Gully, Keilor, below Lower Miocene marine beds (8), at Broadmeadows (47), along the Maribyrnong River at Essendon, at Cape Schanck (bore No. 1, 32 feet), at San Remo, and on Phillip Island.

It consists of microphenocrysts of slightly corroded fresh olivine, set in a groundmass of laths and microlites of plagioclase (Ab_{35}), minute grains of pyroxene, octahedra of iron ore, and abundant brown glass which constitutes over half the rock. The specimens from Essendon and Broadmeadows are identical except that an occasional phenocryst of (?) anorthoclase is present at the latter locality (47). The Cape Schanck and San Remo specimens are rather more crystalline, so that the felspar laths are larger and the pyroxene grains larger and more numerous, while the amount of brown glass is less.

An analysis of the Broadmeadows flow is shown in Table I., No. 10.

Buckland Type.

An unusual type of basalt occurs as pipes and dykes in association with the phonolites and tinguaites of Harrietville. Rather similar rocks occur at Mt. Buffalo, Bogong High Plains, Sandy's Creek in the Tabberabbera district, and Cape Schanck. The dyke at Buckland Gap, near Harrietville, is selected as the type. It contains numerous phenocrysts of plagioclase, augite, and olivine, in a fine-textured groundmass. The plagioclase is labradorite (Ab_{45}), and frequently forms rectangular crystals. They are commonly corroded at the edge and at the core. The augite occurs as greyish-brown, idiomorphic crystals, sometimes 2-3 mm. in diameter. The cores of these crystals are sometimes pleochroic from pale green to yellowish-green. In other instances they are " spongy " with inclusions. Olivine crystals are smaller and less numerous, and are slightly altered to serpentine. The groundmass shows no fluxion structure, and consists of minute rectangular and lath-shaped crystals of labradorite, small grains of augite and olivine, and an interstitial base of minute grains of augite, iron ore, and glass. The other dykes and pipes of the district are similar, although the proportions of the phenocryst minerals vary.

In the rocks from Mt. Buffalo and the Bogong High Plains the proportion of plagioclase phenocrysts is greatly reduced, while the olivine and augite are more abundant, but often corroded. The augite has a marginal zone of titanaugite. At Sandy's Creek, on the other hand, phenocrysts of labradorite dominate. The Cape Schanck rock is closely comparable with Buckland Gap specimen, except that its pyroxene is a purple titanaugite. A somewhat comparable rock occurs at Grange Quarry, Double Creek, near Flinders, but here the phenocryts are solely of a brownish-violet augite, up to 2 mm. in diameter, and the fine-grained groundmass shows fluxion structure. No basalt of this type has yet been met with amongst the Newer Volcanic Series.

At Brandy Creek, near Mt. Bogong, a porphyritic type occurs in which idiomorphic phenocrysts of titanaugite, 10 mm. in diameter, are set in a medium-grained groundmass of corroded olivine, plagioclase laths, small crystals of violet augite, iron ore, and interstitial analcite, which shows weak birefringence.

Berwick Type.

Basalts of this group occur at Berwick, Bogong High Plains, Mt. Fainter, Mahaikah, Mt. Moreton (Belgrave), Korkuperrimul

Creek, Leongatha, Welshpool (Allot. 1 of B), Mt. Jim. and Battery Hill, Cobungra, and among the South Gippsland dykes. The type locality is the upper flow at Wilson's Quarry, Allotment 15 of Berwick.

It is a fine-grained olivine-basalt with microphenocrysts of olivine, more or less corroded, in a groundmass which shows little or no fluxion structure, and consists of olivine, pale violet to colourless augite granules, minute octahedra of iron ore, clear, colourless glass, and small but not very numerous laths of plagioclase (Ab_{35}). Between crossed nicols the rock has a characteristic appearance, small bright spots of olivine standing out in a black base which is flecked with minute, yellow spots (augite) and small grey laths of plagioclase. Rocks of this group are not easily distinguished from certain basalts of the Newer Volcanic Series.

At Berwick large phenocrysts of anorthoclase occur sporadically in the basalt. This feature is found in the Flinders type basalt at Aberfeldy (29), and also in a monchiquite-basalt at Moyarra (29).

Flinders Type.

This, the most widespread of the Older Volcanic basalts which does not carry titanaugite, occurs at Flinders (bore), Connor's Plain, Korkuperrimul Creek, Jindivick (Allot. 19), Grice's Creek, San Remo, Emerald, Mt. Hotham, Cape Schanck (bore), Royal Park, Alberton West (bore 92), Mooroodue (bore No. 9, 109-119 feet), Aberfeldy (Mt. Lookout and along the interfluve between the Thompson and the Jordan Rivers), Mt. Loch (Bogong High Plains), Ruby, Maude, Airey's Inlet, Curlewis, Sylvan, Leongatha, Warragul, Devon, Boolarra, Mt. Buller, Greensborough, Kangaroo Ground, Lilydale, South Buchan, White's Plain (Cobungra), 15 Mile Creek (Dargo), and among the dykes of South Gippsland (10).

Its characteristic feature is the presence of considerable amounts of green glass, generally devitrified, when it appears to be serpentine. It differs from rocks of the Mooroodue type in the absence of titanaugite and ophitic structure, but intermediate variations are to be found. Olivine is usually the only mineral occurring as phenocrysts. In some of the Flinders bore cores it forms crystals 2-3 mm. across, but it is generally smaller. The olivine crystals are nearly always corroded and partially altered to serpentine. Occasional microphenocrysts of brown augite and plagioclase accompany the olivine. Sometimes, as in one San Remo specimen, the plagioclase is more abundant. The groundmass frequently shows fluxion structure, and is an intergranular growth of pyroxene granules, laths of plagioclase (Ab_{40}), iron ore, and the intersertal green glass. The pyroxene varies from colourless to pale violet, when the rock grades into the Mooroodue type. The grain size is rather variable at different localities, and in some instances the green glass is present in only small amount, or may be lacking entirely.

Rocks of this group are not readily distinguished from those of the Trentham type of Newer Volcanic basalt. Moreover, the distinction between the Berwick and Flinders type is based solely upon appearance in thin section. The two rocks are probably chemically similar, as is also the titanaugite-bearing Mooroodue type. Its difference from the Mirboo type is based on the absence of iddingsite, although the analyses (Table I., Nos. 5-8) suggest that the Mirboo type is rather more basic and richer in MgO.

Mugearites.

Mugearitic types are rare among the Older Volcanics, in contrast to their relatively widespread development among the Newer Volcanics. Only two occurrences are known—a pipe at Aberfeldy, described by Mahony (28) as an olivine-andesite, and a dyke on the Dargo High Plains. The felspar laths which constitute a large portion of the Aberfeldy rock are mostly oligoclase with cores of andesine. It undoubtedly belongs to this group, and should be called olivine-andesine basalt (or olivine oligoclase-basalt) rather than andesite. An analysis of the rock is given in Table I., No. 2, but there is some doubt as to whether the analysis quoted is really of this rock. Three analyses were made of the Aberfeldy basalts (Mem. Geol. Surv. Vict., No. 15, p. 44, Analyses 4, 7, 8). Of these, Analysis No. 4, reputed to be of the olivine-andesite, and Analysis No. 8, reputed to be a basalt, do not correspond with their respective thin sections. If, however, the analyses are interchanged, a very good agreement is found. It seems probable, therefore, that some mixing of the specimens has occurred. Accordingly, I have quoted Analysis 8 as representing the composition of the olivine-andesite.

Olivine-nephelinites, nepheline-limburgites and monchiquites.

Rocks of this character are known to occur at several places in the State, namely along Korkuperrimul Creek (20), at Greendale (42), at Drouin West (Allot. 91) (30), in the Bogong High Plains, and at the You Yangs (1). Only in the first of these occurrences is the age relation of the nephelinite beyond doubt. Jacobson (20, p. 134) has shown that at Korkuperrimul Creek there are several flows of olivine-nephelinite which grade laterally into nepheline-limburgites. They overlie flows of the Flinders and Mooroodue type, and are overlain by thin flows of limburgite and olivine-titanaugite-dolerite.

The Greendale occurrence is in the form of a plug intruding Permo Carboniferous glacial beds (42). Apart from its nepheline content, the plug resembles the Older Volcanic monchiquite dykes of this district. The You Yangs occurrence is equally indefinite in age. It consists of a dyke with strongly monchiquitic affinities, accompanying monchiquite dykes which have invaded the You Yangs granite (1). It is probable that similar monchiquites intrude the surrounding Palaeozoic sediments, but are now hidden beneath the Newer Volcanic basalts.

The specimen from the Bogong High Plains is almost identical in appearance with that from the plug at Greendale, but is rather richer in nepheline. It was found by Mr. McCance, but was not in situ, so that its mode of occurrence is unknown. The other basaltic rocks of this area include definitely older Volcanic types.

The olivine-nephelinite at Drouin West, described by Mahony (30), is a plug surrounded by basaltic soil, so that its age is indefinite, although it appears to intrude the Older Volcanic lavas. This rock is a true nephelinite, and lacks the monchiquitic features of those from the other localities. It will be seen from the chemical analyses of Table II., Nos. 1-3, that the difference is expressed by the higher Na_2O content of the Drouin rock. The Korkuperrimul analysis is of a nepheline-poor variety of the type occurring there, and is therefore not truly representative of the soda-content of the olivine-nephelinites proper of that district.

Limburgites and Monchiquites.

Limburgites occur at a number of localities, but are not common as flows. The most extensive flows are in the Korkuperrimul Creek area (20), where they occur beneath basalts of the Flinders type, and above iddingsite-titanaugite basalts, and grade laterally into olivine-nephelinite. True flows or plugs occur at Euroa (? Newer Volcanic), Tommy's Hut, and Balwyn, and in the vicinity of Greendale. Other specimens in the collection are from Ensay, Broadford, the Basalt Temple on the Bogong High Plains, Mt. Hotham, Drumblemara (stone reserve), Mt. Deddick, Buchan (Allot. 10-18), the Buffalo Mountains (Crystal Brook), the Maude Mine at Glen Wills, the Blackwall Mine at Toombon, Harrietville (Rose, Thistle, and Shamrock Mine), Harkaway (N. of Berwick), and Parwan Creek (Yaloak). Most of these are from dykes, and they closely resemble the dykes of monchiquite in South Gippsland, Bendigo, Maldon, and Daylesford districts. In some instances they are clearly older than the Newer Volcanics, as at Yaloak and Greendale, but more often their relation is indefinite. However, it is to be noted that dykes appear to be rare among the Newer Volcanic lavas, although small flows are fairly numerous, as at Macedon, Woodend, Gisborne, Romsey, and Springfield (12). There is little, if anything, to distinguish between the limburgites of these two series petrologically.

Camptonites.

Dykes of camptonite are known to occur at Greendale, Daylesford, Bendigo (48), between Ensay and Jambarra, at Orr's Creek near Dargo, at Nedside on Livingstone Creek, and at Forest Hill, South Yarra.

The Greendale dyke intrudes the Ordovician in Dales Creek close to the plug of nephelinite, and is associated with dykes of monchiquite and olivine-basalt. It differs from the monchiquites in the presence of numerous microphenocrysts and wisps of brown hornblende and biotite, subordinate laths of plagioclase, and interstitial areas of felspar which may be anorthoclase. In this respect it is similar to the Bendigo camptonites. Some of the titanaugite crystals have cores of emerald green pyroxene which is pleochroic to yellow green, and appears to be aegirine. It differs from the biotite-lamprophyre at the freehold Mine, Daylesford, only by the absence of coarse crystals of biotite.

Slides of a similar rock from a locality called Ferntree Gully on the track from Ensay to Jambarra, were found in the Howitt Collection (in the Melbourne University). In these, however, the hornblende is restricted to numerous laths and wisps in the groundmass, and is accompanied by more aboundant biotite. Allied dykes in Orr's Creek and Livingstone Creek contain abundant crystals of brown hornblende and biotite. In the section from Livingstone Creek the hornblende crystals are frequently as large as 3 mm. in diameter, and are accompanied by titanaugite crystals of the same dimensions. The titanaugites, like those in the Greendale rocks, have cores pleochroic from deep green to greenish-yellow. No plagioclase occurs in these latter two specimens, however, so that they represent an intermediate stage between the camptonite proper and the monchiquites. The gradation from the other end, by the development of "ocellar" patches of sub-radiate hornblende laths and analcitic glass, has been noted in the dykes of monchiquite at Bendigo (48) and South Gippsland (10).

Acid Differentiates.

There has developed a tendency to regard all the Tertiary alkaline rocks in Victoria as belonging to a single Middle Kainozoic Alkaline Series, distinct from both the Older Volcanic and the Newer Volcanic Series (e.g. 50, p. 25). This is, however, a misunderstanding of the facts, which appears to have grown from a statement made by Professor Skeats in 1910, when referring to the difference in age between the Macedon dacites and the Macedon alkali rocks, namely: "The Alkali Series is a much younger one, of probably Mid-Kainozoic age, since the later rocks merge into the newer basalts" (Newer Volcanics) (39, p. 203). In the same paper he suggested that the similar alkali rocks in the Western District "may be of the same age as the Macedon rocks" (p. 204), while in 1912 (45, p. 53) and 1914 (40), it was further suggested that a number of the isolated occurrences of phonolite, tinguaite, and solvsbergite might also be of the same age as the Macedon rocks.

It is unlikely, however, that all the Tertiary alkaline rocks in Victoria were extruded simultaneously, and in some localities there is proof that they were not. Petrogenetic studies of the Newer Volcanic Series in Central Victoria (12) have made it clear that the solvsbergites, trachytes, trachyphonolites, and trachyandesites of Macedon, Trentham, Tylden, Bullarto, Coliban, and Gisborne, are the typical acid-differentiation products of the olivine-basalt lavas with which they are associated, and the same seems to be true for the trachytes of the Western District. Such associations are characteristic of olivine-basalt provinces throughout the world (46), and are to be expected wherever conditions have permitted more or less complete "cupola differentiation" to take place (11, 13). The time most favorable to complete differentiation is generally that immediately preceding the beginning of extrusion. Subsequently the main magma reservoir is thought generally to have approached so close to the surface that further extrusion occurs before there is time for repeated advanced differentiation. Thus it is that the greatest development of alkaline types in olivine-basalt provinces throughout the world has been during the early stages of extrusion (46). The Newer Volcanic lavas of Victoria are no exception in this respect.

As indicated above, the alkaline lavas are pictured as centred above cupola-like protrusions of the main magma reservoir. Although in each locality in which they occur they will be among the early extrusions from that cupola, it is unlikely that all the cupolas of a province will develop at the same time and rate, so that there will be no definite period of alkaline extrusions. Moreover, if extrusion is interrupted for a sufficiently long period, renewal of differentiation within the magma reservoir may give rise to later alkaline rocks, as it has done at Coleraine and Casterton (40), and at Gisborne.

A feature of the Tertiary alkaline rocks of Victoria is that those which definitely belong to the Newer Volcanic period are predominantly trachytes or have trachytic affinities, while those which outcrop in Eastern Victoria, in proximity to the Older Volcanic lavas, are predominantly phonolitic or have affinities with phonolites. This may be a coincidence, but it assumes significance in view of the richness of the Older Volcanics in soda, expressed by the development of olivine-nephelinites, analcite-basalts, and crinanites, as contrasted with the relative richness of the Newer Volcanics in potash, as indicated by the development of macedonites, mugearites, and woodendite. This raises the possibility that the isolated occurrences of alkaline rocks in Eastern Victoria may, at least in part, be acid differentiates of the Older Volcanic Series.

The alkaline rocks most likely to belong to the Older Volcanic Series are the pipes and dykes of phonolite, sodalite-phonolite, and tinguaite near Harrietville (42), which occur in association with pipes and dykes of olivine-basalt of the Buckland type. These pipes are from 50 feet in diameter, up to 20 acres in extent. The rocks composing some of them differ from the alkaline rocks in other parts of Victoria in that they contain numerous phenocrysts of basaltic hornblende which is reacting with the groundmass to form aegirine and iron ore. In a number of instances the brown basaltic hornblende, which shows straight extinction, remains only as a core to a deep green hornblende with an extinction angle of 20°. The alteration is transitional, so that there can be little doubt as to the sodic character of the green hornblende. This development of basaltic hornblende in phonolites, with subsequent alteration to aegirine, appears to be a characteristic feature of many phonolites and allied alkaline lavas. Its restriction to strongly differentiated types has led the author to suggest that it forms during the cupola stage of differentiation of a basaltic magma (13).

Other acid alkaline types which may belong to the Older or Newer Volcanic Series are a dyke of phonolite from Dargo flat (Howitt Coll.) (43), the phonolite and tinguaite dykes of Tabberabbera (44), the phonolites, tinguaites, trachytes, and solvsbergites of Omeo (40), the biotite-phonolite of Gallows Hill, near Mahaikah, in the Mansfield district (40), and possibly the trachyte-solvsbergite dykes and syenite of Mt. Leinster (2). This is, of course, purely conjecture, particularly since Newer Volcanic lavas occur in the region, as at Benambra and Gelantipy (18).

Pyroxenes.

No very definite statement can be made as to the composition of the pyroxenes. Approximate measurements of 2V were made (by comparison of acute bisectrix figures with such figures for minerals of known 2V; muscovite and aragonite) wherever possible. These gave values of 2V about 60° for the titanaugites, but in the basalts without titanaugite the pyroxene grains were generally too small for determination. Such measurements as were achieved gave values of 2V of about 50–60°, and such pyroxenes were presumed to be diopsidic. No pigeonites were observed.

Chemical Compositions.

Analyses of the Older Volcanic rocks are not as numerous as could be desired. The chemical compositions of the dyke rocks in South Gippsland and Bendigo have been given elsewhere (10, 48). In the two tables that follow (Tables I. and II.), all the existing analyses of Older Volcanic basalts other than these are set out. They are too few for well-defined groups to show out, but suggest that the differences between the Moorooduc, Flinders, Mirboo, and Keilor types are petrographical rather than chemical. This probably applies to the Berwick type also.

Table I.

——	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
SiO_2	47·70	45·29	51·31	46·64	47·89	46·04	45·64	46·43	44·91	44·95
Al_2O_3	17·76	19·83	18·03	15·46	16·16	15·08	14·35	17·60	13·77	15·50
Fe_2O_3	2·23	4·90	1·50	4·49	2·00	5·08	2·08	8·51	5·28	2·04
FeO	8·25	6·43	7·32	7·25	8·88	6·95	10·32	2·44	5·81	10·47
MgO	6·50	2·49	5·60	7·24	6·23	7·02	9·50	8·03	12·19	7·43
CaO	9·37	9·80	8·74	10·80	10·39	7·75	7·87	8·12	8·56	8·24
Na_2O	3·34	4·24	3·30	2·43	3·37	3·76	2·17	3·56	1·73	3·04
K_2O	1·59	1·96	2·26	0·92	1·47	2·41	1·23	0·92	0·94	1·98
H_2O+	0·85	1·02	0·79	1·83	1·34	1·20	1·92	1·20	3·40	2·60
H_2O-	0·27	0·38	..	0·89	0·15	0·57	1·29	0·81	1·34	0·52
CO_2	tr.	nil	0·88	tr.	nil	nil	0·47	nil	tr.	0·18
TiO_2	1·02	2·35	tr.	1·90	1·75	2·78	2·74	2·25	1·73	2·77
P_2O_5	0·51	0·62	0·45	0·32	0·78	1·44	0·42	0·37	0·32	0·52
MnO	0·24	0·23	tr.	0·04	0·19	0·28	0·13	0·22	0·33	0·21
Li_2O	..	..	..	..	..	..	..	..	tr.	..
Cl	0·03	tr.	..	..	tr.	tr.	0·02	..	nil	..
S	0·02	nil	..	..	tr.	tr.	0·14	..	nil	..
BaO	0·03	..	..	..	..	..	nil	..	..	..
Total ..	99·69	99·45	100·18	100·21	100·60	100·36	100·40	100·53	100·39	100·45

(1) Corrected for Cl, S

(7) Cr_2O_3 ·01
V_2O_5 ·05
SrO ·02
ZrO_2 ·03
NiO ·07

(9) NiO ·03
CoO tr.
Cr_2O_3 ·05

1. Crinanite dyke (not rich in analcite), creek west of Gibson's allotment, Kilcunda. Analyst—A. B. Edwards (*Proc. Roy. Soc. Vic.*, 47, 1, p. 123, 1934).
2. Mugearite pipe, Binn's Creek, Aberfeldy. Analyst—W. L. Robertson (Mem. Geol. Surv. Vic., 15, p. 45, 1925). (See note p. 85.)
3. Tachylyte, Tanjil. Analyst—A. W. Howitt (Vic. Nat., 2, p. 67, 1885).
4. Mooroodue type, porphyritic variety, Korkuperrimul Creek. Analyst—R. Jacobson (*Proc. Roy. Soc. Vic.*, 50, 1, 1937).
5. Flinders type, Mt. Lookout, Aberfeldy. Analyst—M. K. Evans (Mem. Geol. Surv. Vic. 15, p. 45, 1925).
6. Flinders type, Mt. Lookout, Aberfeldy. Analyst—M. K. Evans (Mem. Geol. Surv. Vic., 15, p. 45, 1925).
7. Flinders type, railway cutting, Royal Park, Melbourne. Analyst—W. McCance (*Proc. Roy. Soc. Vic.* 44, 2, 1932).
8. Flinders type, fine-grained flow, Greensborough. Analyst—N. R. Junner (*Proc. Roy. Soc. Vic.*, 25, 2, p. 335, 1913).
9. Mirboo type, Berry's Creek Bore, No. 20, depth 90 feet, allot. 34, Mardan. Analyst—A. G. Hall (Ann. Rept. Sec. Mines, 1911, p. 62).
10. Keilor type, Quarry, section xv., Tullamarine (Broadmeadows). Analyst—F. L. Stillwell (*Proc. Roy. Soc. Vic.*, 24, 2, 1912).

TABLE II.

——	1.	2.	3.	4.	5.	6.
SiO_2	41·13	42·39	39·79	44·67	44·56	45·56
Al_2O_3	15·74	16·17	12·11	12·39	11·68	13·32
Fe_2O_3	4·02	4·29	4·67	3·96	3·95	2·30
FeO	7·71	5·79	7·87	7·53	6·88	9·68
MgO	7·98	7·66	12·25	9·67	11·91	11·12
CaO	10·48	11·57	11·29	10·16	10·37	8·77
Na2O	5·56	4·26	2·83	1·84	1·03	3·02
K_2O	1·12	1·46	1·23	1·85	2·31	1·53
H_2O + ...	2·11	1·85	1·79	3·92	2·97	1·28
H_2O −	0·58	0·56	3·06	0·92	0·84	0·27
CO_2	nil	nil	nil	tr.	nil	nil
TiO_2	2·34	2·13	1·87	2·52	2·90	3·00
P_2O_5	0·54	1·16	1·30	0·14	0·40	0·71
MnO	0·14	0·23	0·02	tr.	0·24	0·19
Li_2O	tr.	..	..	..	tr.	nil
SO_3	nil	..	..	0·15	..	nil
S	..	0·13	..	0·47	0·06	..
Cl	nil	0·11	..	tr.	tr.	0·05
BaO	..	0·01	..	..	..	..
NiO, CoO	..	nil	..	..	0·01	0·01
Cr_2O_3	..	0·03	..	..	0·09	0·06
V_2O_3	..	0·01	..	..	..	..
TOTAL ..	99·45	99·70	100·08	100·19	100·20	100·87

1. Olivine-nephelinite, Allotment 91, Parish of Drouin West, plug. Analyst—F. F. Field (*Proc. Roy. Soc. Vic.*, xliii., 2, p. 128, 1930).
2. Olivine-nephelinite, plug 8 chains S. of Greendale Hotel, Parish of Blackwood. Analyst—A. B. Edwards (*Proc. Roy. Soc. Vic.*, xlvii., 1, p. 123, 1934).
3. Olivine-nephelinite, lava flow (limburgitic phase), 50 yards from the head of a small gully on the western slopes of Bald Hill, Bacchus Marsh. Analyst—R. Jacobson (*Proc. Roy. Soc. Vic.*, 50, 1, p. 145, 1937).
4. Limburgite, dyke, Blackwall Mine, Aberfeldy. Analyst—M. K. Evans (Mem. Geol. Surv. Victoria, No. 15, p. 44).
5. Limburgite, small flow, Euroa. Analyst—A. G. Hall (Ann. Rept. Sec. for Mines, for year 1912, p. 62).
6. Limburgite plug at Balwyn. Analyst—P. W. G. Bayley (*Proc. Roy. Soc. Vic.*, xxiv., n.s. 1, p. 133, 1911).

If analyses 1, 2, and 3 of Table I., and all of Table II. are excepted as differentiated types, then the average of the remainder (Table I., Nos. 4-10) which are the widespread, little differentiated types, gives a composition which may be regarded as approximating to the composition of the "parent magma" of the suite. This shown in Table III. below:—

TABLE III.

——	Older Volcanic Magma type.	Newer Volcanic Magma type.	Olivine-basalt Magma type.	Tholeiite Magma type.
SiO_2	46	50	45	50
Al_2O_3	15·5	15	15	13
FeO, Fe_2O_3	11·5	11·5	13	13
MgO	8	8·5	8	5
CaO	8·8	8·5	9	10
Na_2O	2·9	3·0	2·5	2·8
K_2O	1·4	1·2	0·5	1·2

From this it seems probable that the parent magma of the Older Volcanic Series approximates to the "olivine-basalt magma type" (26), and is also fairly comparable with the parent magma of the Newer Volcanic Series. This, however, as indicated by its SiO_2 content, is more nearly intermediate between the olivine-basalt magma type and the tholeiitc magma type. The Older Volcanics show little resemblance to the tholeiites.

Comparison with Other Tertiary Lavas in Victoria.

It remains to compare the Older Volcanic Series with the other Tertiary igneous rocks of Victoria.

Newer Volcanic Series.

There is a general similarity between the Newer and the Older Volcanic Series in that both are olivine-basalt associations, and gave rise to alkaline end-products. There are, however, some outstanding differences:—

1. Existing analyses indicate that the basalts of the Older Volcanic Series approach more closely to the olivine-basalt magma type in composition than those of the Newer Volcanic Series, which have tholeiitic tendencies.

2. The dominant basalts of the Newer Volcanic Series (Malmsbury and Footscray types) are characterised by an abundance of iddingsite and a paucity of titanaugite (12). On the other hand, titanaugite is the common pyroxene of many Older Volcanic basalts, while iddingsite is of only local occurrence.

3. Crinanites are unknown among the Newer Volcanics, but are widespread among the Older Volcanics.

4. Such Newer Volcanic basalts as do not contain iddingsite are generally associated with more completely differentiated types, such as mugearites, trachyandesites, and trachytes.

5. Mugearites are prominently developed among the Newer Volcanics, but are rare among the Older Volcanic rocks. This finds further expression in the fact that the differentiated Newer Volcanic types are rich both in soda and potash, while the comparable rocks among the Older Volcanics are rich in soda.

6. Basic alkaline types are only weakly developed among the Newer Volcanics, where some limburgites contain analcite. Among the Older Volcanics, however, olivine-nephelinites are of relatively frequent occurrence.

7. Dykes are uncommon among the Newer Volcanics, but are prevalent among the Older Volcanic rocks.

8. The Newer Volcanic basalts are relatively fine-grained, and generally have intergranular textures. The Malmsbury and Footscray types are greyish in colour when fresh, and often vesicular, while the Trentham type and mugearites are bluish-green when fresh. The titanaugite members of the Older Volcanic basalts, on the other hand, generally possess ophitic textures, and are frequently relatively coarse-grained. Older Volcanic basalts are rarely vesicular, and are generally dark coloured, so that they possess a distinctive appearance even in the hand specimen.

There can be little doubt, therefore, as to the difference between these two suites of Tertiary lavas. It cannot, of course, be claimed that the petrological examination of any specimen is sufficient to assign it to one or other suite, but for a number of rock types this is so, and fortunately these types occur in a number of areas.

Suggested Intermediate Series.

Jutson (23) has suggested that on physiographic grounds the basalts at Ivanhoe and Greensborough, and possibly those at Kangaroo Grounds, are of Pliocene age, and intermediate between the Older and Newer Volcanics. The Greensborough and Kangaroo Ground basalts have been described by Junner (21). The basalts at both localities include ophitic olivine-titanaugite dolerites, identical with those of the Older Volcanic Series, and an identical type occurs as a small residual at Diamond Creek in the same district. In view of the uncertain nature of Jutson's evidence, it seems probable to the author that these residuals are Older Volcanic and not Pliocene.

Other Gippsland Localities.

The lavas in the Gelantipy area, and those in the neighbourhood of Benambra, shown as Newer Volcanic on the 8 miles to an inch map of Victoria of 1902, and as Older Volcanic on the 16 inch maps of 1909 and 1936, appear on petrological evidence to be Newer Volcanic. Iddingsite basalts of the Malmsbury-Footscray group are found at both localities, together with less distinctive types. This agrees with the physiographic evidence (18).

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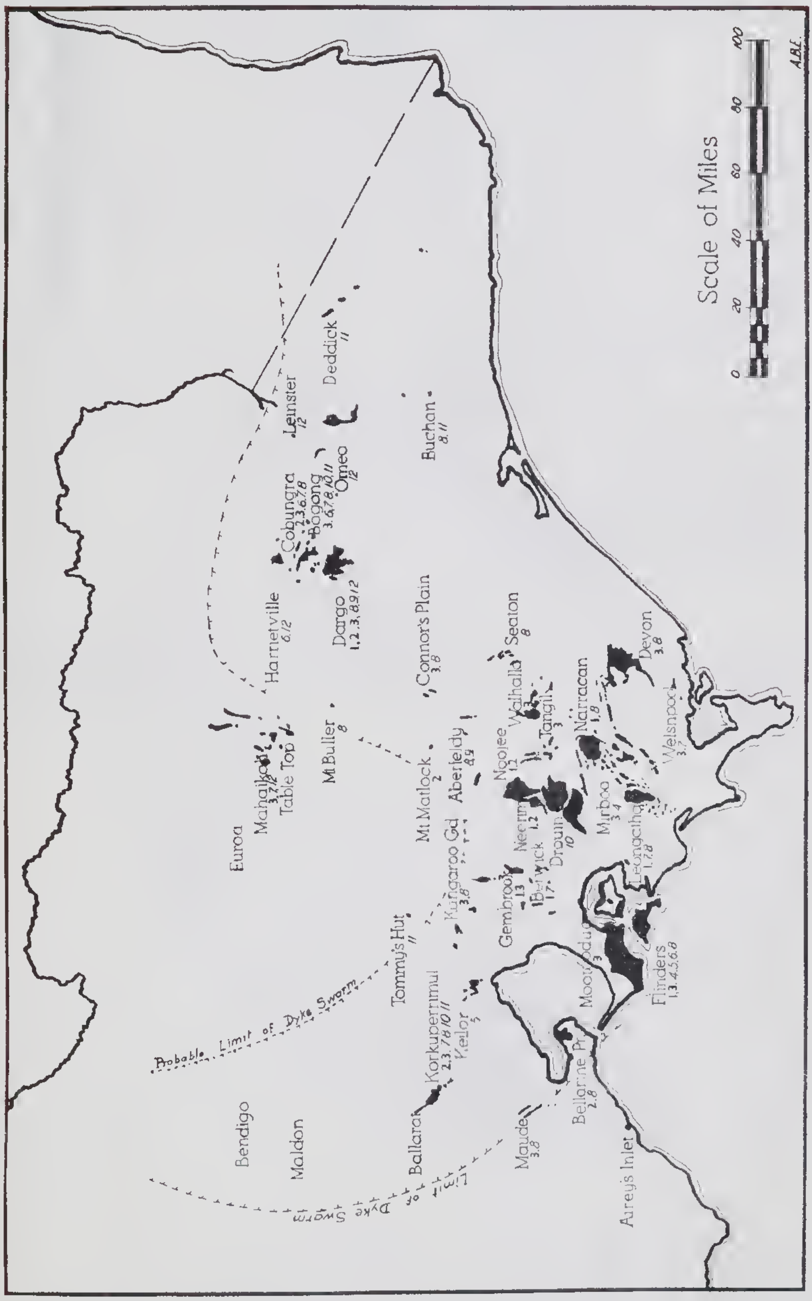
Scale of Miles
0
20
40
60
80
100
Bendigo
Maldon
Euroa
Table Top
Harrietville
Cobungra
Bogong
Omeo
Leinster
Deddick
Buchan
Dargo
Mt Buller
Connor's Plain
Mt Matlock
Aberfeldy
Seaton
Walhalla
Tanjil
Narracan
Devon
Welshpool
Noojee
Neerim
Drouin
Mirboo
Leongatha
Berwick
Gembrook
Tommy's Hut
Keilor
Ballarat
Maude
Aireys Inlet
Flinders
Probable Limit of Dyke Swarm
Limit of Dyke Swarm

Fig. 1.

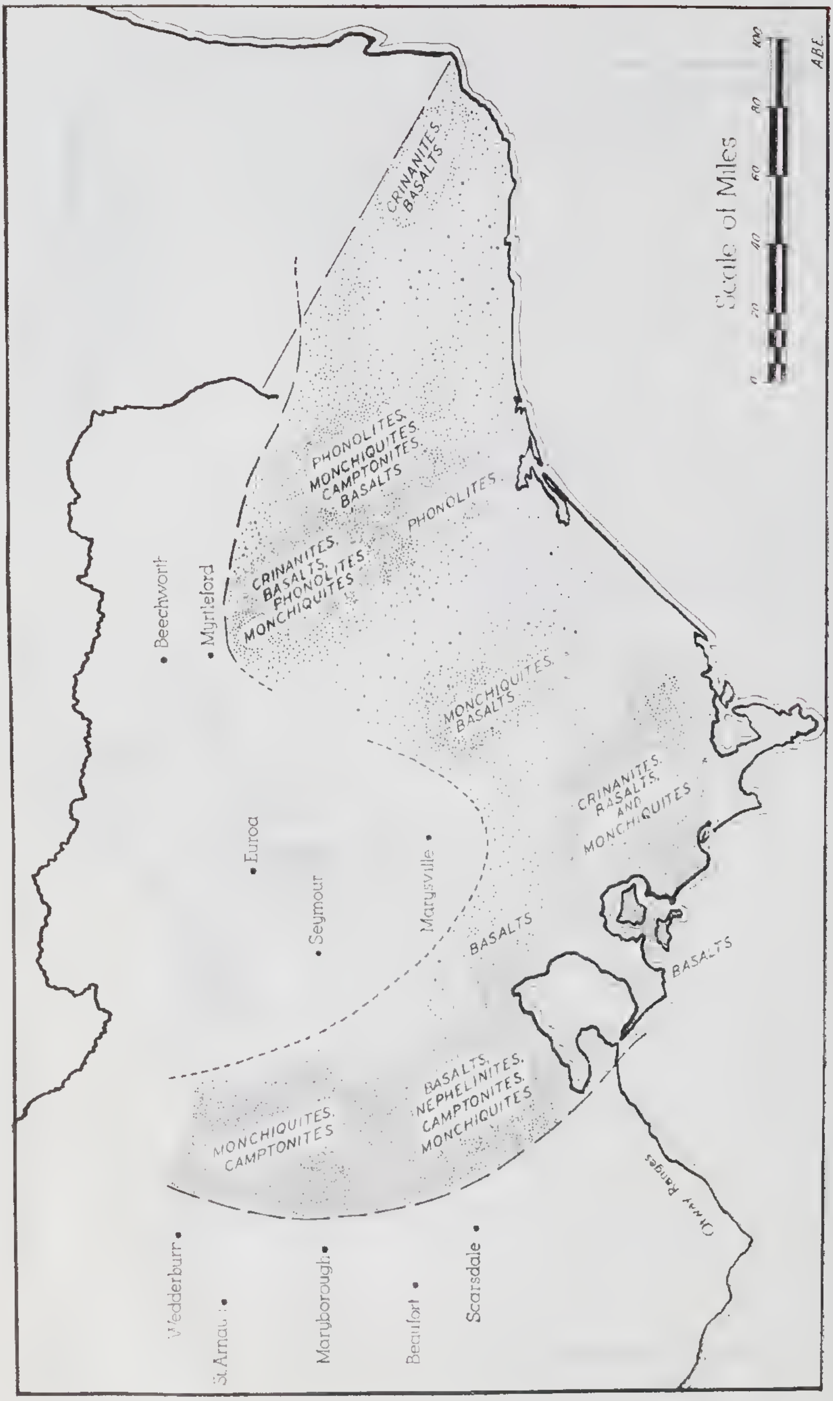
CRINANITES. BASALTS
PHONOLITES. MONCHIQUITES. CAMPTONITES. BASALTS
PHONOLITES.
CRINANITES. BASALTS. PHONOLITES MONCHIQUITES
MONCHIQUITES. BASALTS
CRINANITES. BASALTS. AND MONCHIQUITES
BASALTS
BASALTS
BASALTS. NEPHELINITES. CAMPTONITES. MONCHIQUITES
MONCHIQUITES. CAMPTONITES
Beechworth
Myrtleford
Euroa
Seymour
Marysville
Wedderburn
St. Arnaud
Maryborough
Beaufort
Scarsdale
Otway Ranges
Scale of Miles
0
20
40
60
80
100
ABE.

FIG. 2.